



Integration of the concept of STEM/STEAM education into the professional training of future specialists in the field of tourism and recreation: Opportunities and challenges

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■ **Abstract.** The study aimed to identify ways to improve the professional training of future specialists in the field of tourism and recreation and to form the necessary competencies through the introduction of the concept of STEM/STEAM education. The research methodology incorporated qualitative and quantitative data collection methods, including surveys of learners and educators, curricula analysis, and educational process observations. These approaches facilitated the collection of qualitative and quantitative data through questionnaires to explore participants' experiences, attitudes, and opinions. The main findings revealed that integrating STEM education into vocational training significantly supports the development of key skills required in the modern world, such as creativity, critical thinking, technical literacy, and interdisciplinary collaboration. It was found that learners enrolled in STEM programmes exhibit higher levels of motivation for learning, driven by the application of practice-oriented approaches and innovative technologies. The study highlighted several challenges, including insufficient preparation of educators for STEM-based teaching methods and limited resources, which hinder the effective implementation of such programmes. The research highlighted the importance of support from educational institution administrations and the necessity of collaboration with partners for the successful integration of STEM education. Despite these challenges, the potential of STEM education remains substantial, provided there is adequate support and adaptation to local conditions. A significant finding was that STEM education holds considerable promise for improving vocational training, even though its implementation is accompanied by certain obstacles. The study emphasised the importance of continuous professional development for educators, the provision of necessary resources, and the active involvement of all stakeholders in the process to ensure the effective integration of STEM education. The insights gained from this research can be utilised by educational institutions to implement innovative teaching methods and create favourable conditions for developing the skills required in the modern world

■ **Keywords:** concept of STEM/STEAM education; vocational education; future specialists in tourism and recreation; innovative technologies; integrated approach; interdisciplinary programmes; professional competence

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■ Introduction

The contemporary world demands that professionals possess not only a deeper theoretical knowledge but also the ability to apply this knowledge in practice, solve complex problems, and implement innovations. STEM education (Science, Technology, Engineering, Mathematics) contributes to the development of such skills as it integrates various scientific disciplines, stimulates critical thinking, and fosters innovation. The integration of STEM education into vocational training is becoming increasingly relevant given the rapid development of technologies and the growing demands on professionals in various fields. This ensures not only the training of competitive personnel but also contributes to the economic development of every country. The integration of STEM education into vocational training is accompanied by several challenges and opportunities. It opens up new horizons for learners, allowing them to master modern technologies and methods that are necessary for a successful career. But there are problems associated with adapting curricula, training teaching staff, providing the necessary material and technical base, and supporting innovative teaching methods. Research into these issues is key to creating an effective system of vocational training that meets the demands of the modern labour market and promotes the development of innovative approaches in various fields.

The integration of STEM education into vocational training is one of the most debated topics in contemporary pedagogy and educational policy. Numerous studies underscore the importance of STEM education for fostering innovation, economic growth, and enhancing graduates' competitiveness in the job market. Researchers E. Cevik *et al.* (2021) explored the opportunities and challenges associated with the application of STEM education in the learning process. The researchers identified significant advantages of STEM education, highlighting its multifaceted nature. They noted that this education contributes to the development of critical thinking, which is essential for solving complex problems. STEM education stimulates innovation and creativity, which are key competencies in the technological world. Scientists N. Balyk *et al.* (2022) further complemented this idea, noting that STEM education helps learners acquire practical skills that are directly applicable to manufacturing and engineering processes. One of the key challenges faced by educational institutions when implementing STEM education is the need to train highly qualified educators capable of integrating an interdisciplinary approach to teaching. Research by E. Fokides & G. Lagopati (2024) indicated the importance of providing access to modern technologies and laboratory equipment, enabling learners to apply theoretical knowledge in practice. Another crucial aspect is support from government and private companies, which can contribute to funding STEM education programs and providing opportunities for internships

and placements. Such collaboration fosters the development of professionals who can quickly adapt to changes in the job market, as noted by G. Martinez-Borreguero *et al.* (2022). Integrating STEM education into vocational training is accompanied by several challenges. One of the most significant challenges is adapting curricula. According to research by M.M. Marques & L. Pombo (2021), existing programs need to be significantly modified to integrate STEM components, which requires time and resources. Another challenge is the preparation of future educators. Teachers of specialised disciplines of the tourism studies cycle should not only have in-depth knowledge of their disciplines, but also be able to integrate interdisciplinary approaches into teaching. Material and technical resources are also a crucial aspect. Effective STEM education requires modern laboratories, computer classrooms, and other technical equipment, which demands significant financial investment (Ezzeldin, 2022). It is important to ensure that all learners have access to these resources, which can be a challenge for institutions with limited budgets.

Researchers such as C.I. Pappa *et al.* (2024) have found that the implementation of new teaching methods is also critical for the successful integration of STEM education. Studies indicate that active learning, project-based methods, and interdisciplinary projects are effective approaches to teaching STEM subjects. Implementing these methods requires a shift from traditional pedagogical practices, which may face resistance from educators and administrators. Evaluating the effectiveness of STEM education integration is another crucial aspect. There is a need to develop new tools for assessing the quality of learning and the level of STEM competency attainment among learners. A. MacDonald *et al.* (2023) emphasised that the integration of STEM education into vocational training is necessary to ensure a high level of graduate competence and competitiveness in the job market. It opens up new opportunities for learners but is accompanied by significant challenges that need to be addressed. Successful integration requires changes to curricula, educator training, material and technical resources, and teaching methods. It is essential to develop effective methods for evaluating the quality of STEM education to ensure its sustainable development and positive impact on vocational training. The aim of this study was to explore the opportunities and challenges of integrating STEM education into vocational training and to develop recommendations for optimising this process.

■ Materials and Methods

The research into the integration of STEM education into vocational training focused on the use of a survey method to collect qualitative and quantitative data. The survey was chosen as the primary method due to its effectiveness in gathering large amounts of information

in a relatively short period. A questionnaire was developed that included both closed and open-ended questions to obtain information about the experiences, attitudes, and opinions of survey participants regarding the integration of STEM education. The first stage of the research involved defining the target audience, which consisted of educators, learners, and administrative staff from educational institutions where STEM education had already been introduced or was planned for implementation. A total of respondents from various regions were involved namely Kyiv, Kharkiv, Chernihiv, and Sumy. This allowed for a comprehensive and multifaceted view of the opportunities and challenges of integrating STEM education. The selection of regions was based on their diversity in geographical, economic, and cultural aspects, allowing for a complete picture of the integration of STEM education into vocational training. The regions were chosen to include representatives from across Ukraine (west, centre, east, south, and north), ensuring data diversity and accounting for regional educational characteristics. Regions with different levels of economic development were included in the sample to assess the impact of economic factors on the implementation of STEM education. For example, Kyiv and Kharkiv regions as economically developed regions, as well as less developed regions such as Chernihiv and Sumy. Regional educational traditions and experience in implementing innovative approaches in the educational process were taken into account. This allowed for obtaining a variety of data regarding the acceptance and adaptation of STEM education. The cultural characteristics of the regions were also considered to assess their impact on the process of integrating STEM education.

The study was carried out following the standards outlined in The Declaration of Helsinki (2013). Respondents were selected from a single professional field to gather the necessary information on the research problem. Participants were chosen from various regions of Ukraine to ensure sample representativeness and to account for regional specificities in the educational process. Respondents from the western, central, eastern, and southern regions of the country were involved, allowing for a diverse perspective on the integration of STEM education. The total number of respondents was 300, including 150 men and 150 women. Respondent ages ranged from 20 to 60 years, with an average age of approximately 35. This wide age range allowed for consideration of the opinions of both young specialists and experienced professionals. The selection of respondents took into account their professional activities, work experience, and level of awareness of STEM education, enabling the collection of comprehensive information on various aspects of integrating this approach into vocational training. Respondents were selected through educational institutions, professional associations, and social media, ensuring broad geo-

graphical and professional representation in the study. The questionnaire was divided into several sections, each aimed at exploring a specific aspect of STEM education integration. The first section included questions related to general information about respondents, such as their professional activities, work experience, and level of awareness of STEM education. Subsequent sections were aimed at studying specific aspects of STEM education integration, including its impact on learner motivation, the development of critical and creative thinking, and the challenges faced by educators when implementing this approach. The survey was conducted in an online format, which allowed for the involvement of a larger number of respondents and ensured the anonymity of responses. The collected data was analysed using statistical methods such as frequency analysis and correlation analysis to identify patterns and trends. Openended responses were subjected to content analysis, which allowed for the identification of the main themes and issues raised by learners.

■ Results

STEM education is an innovative approach to learning that integrates five key disciplines: Science, Technology, Engineering, and Mathematics. This approach aims to create an interdisciplinary learning environment where learners can simultaneously study various subjects, applying their knowledge in practice to solve real-world problems. Key characteristics of STEM education include an emphasis on creativity, critical thinking, collaboration, and innovation. It encourages learners to develop new ideas, fosters problem-solving skills, and increases motivation to learn. The global economy and overall human well-being are based on science, technology, engineering, and mathematics. These fields form the foundation of industry, food production, healthcare, and many other aspects of life. These sectors require a constant supply of skilled professionals to drive scientific and technological progress.

There is a growing discourse in the West about the STEM skills gap, and this trend is expected to intensify in the coming years. Specifically, the Academy of Engineering Sciences of Ukraine (n.d.) reported that the United Kingdom will need to train over 100,000 STEM learners by 2020 to meet demand. Another study revealed a shortage of 210,000 talents in mathematics, computer science, science, and technology in Germany. Consequently, developed nations such as Australia, the United Kingdom, Israel, China, South Korea, Singapore, the USA, and EU countries have implemented national STEM education plans. For instance, the USA, through its "Strategic Plan for the Development of STEAM Education", aims to increase the proportion of learners participating in STEAM to 50% by 2020 and train 100,000 new STEAM educators, according to a Mind study (Kukharevska, 2020).

STEM education began to be implemented in Ukrain-

ian universities around the mid-2010s. The concept of STEM education officially started to develop in Ukraine after the Ministry of Education and Science of Ukraine recognised the need to integrate these disciplines into curricula to train specialists capable of working in the context of modern technological changes (STEM-education, n.d.). In particular, the National STEM Project was launched in 2017, aimed at developing STEM education at all levels, including higher education. As part of this project, universities began to more actively implement STEM programs and integrate relevant courses and curricula into the educational process. However, the full implementation of STEM education in universities depends on the specific institution and speciality. Some universities began adapting their curricula to these requirements earlier, while others actively joined the process after 2017.

The frequency of traditional methods in vocational training varied. Trends in their use before the introduction of STEM education were as follows: lecture-based teaching (40%), seminars and practical sessions (25%), online learning (15%), project-based learning (10%), modular learning (5%), and internships and practical work (5%). These data illustrate, that traditional methods, such as lectures and seminars, are the most common, but modern approaches like online learning, project-based learning, and STEM education also occupy a significant share in the educational process.

STEM education differs from traditional approaches by focusing on the integration of various disciplines, rather than teaching them as separate subjects. This allows learners to understand the connections between different fields and the nature of their interaction in the real world. For example, a project in the tourism and recreation industry may include elements of geography, mathematics for calculations, logistics for design, technology for model making, and art for aesthetic design. Such an approach fosters a deeper understanding of the material and develops learners' abilities for creative and critical thinking. A crucial component of STEM education is its practical orientation. Learners are engaged in a variety of projects, experiments, and research, allowing them to apply theoretical knowledge in practice. This helps them develop skills that are essential for the modern job market, including technical abilities, teamwork, effective communication, and project management. Additionally, STEM education contributes to the formation of an interdisciplinary approach to problem solving in tourism education students, which is key in many contemporary professions. STEM education is a powerful tool for preparing learners for the challenges of the future as it combines the theoretical knowledge and practical skills necessary for successful careers in various fields. Table 1 presented data from a survey of respondents based on their professional fields, work experience, and level of awareness of STEM education.

Table 1. Survey results of study participants according to the first stage

Aspect of the question	Response options	Responses from participants, %
Professional field of respondents	Science	25%
	Technology	20%
	Engineering	15%
	Arts	10%
	Mathematics	15%
	Other	15%
Work experience of participants	Less than 1 year	10%
	1-5 years	30%
	5-10 years	25%
	More than 10 years	35%
Level of awareness of STEM education	Very well aware	40%
	Well aware	30%
	Generally aware	20%
	Little aware	10%

Source: compiled by the authors

The majority of participants in the study were from the science and technology sectors. This may be due to the traditionally strong links between STEM education and these fields. Engineers and mathematicians also represented a significant proportion, while the arts constituted a smaller fraction. This could indicate less integration of the arts into STEM education or a lower interest among representatives of artistic professions. The distribution of participants by work experience shows that most respondents have considerable experience in their professional activities:

slightly more than a third have over 10 years of experience, and a quarter have between 5 and 10 years. This suggests that the study captures the opinions of experienced professionals, which is crucial for obtaining a thorough assessment of STEM education integration. Young specialists with less than a year of experience make up a small percentage, allowing their perspectives to be considered as well. A significant portion of respondents indicated that they were well or very well informed about STEM education, suggesting a high level of awareness among the study participants.

A quarter have a general understanding, while a small percentage are less familiar with the topic, indicating a need for further dissemination of information and training on STEM education. These percentages provide an idea of the professional composition, experience, and level of awareness of the respondents, helping to better understand the context of the study and draw informed conclusions.

STEM education, with its focus on science, technology, engineering, and mathematics, plays a crucial role

in preparing professionals capable of adapting to contemporary labour market challenges. The importance of this approach is growing due to its ability to develop critical thinking, creativity, and interdisciplinary skills. Figure 1 presented the necessary data collected during the research, confirming the positive impact of STEM education on the formation of professional competence and managerial competence of applicants, as well as identifying the obstacles faced by educational institutions when integrating this approach.

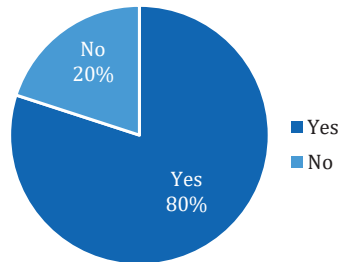


Figure 1. Results of respondents' answers to the question "Have you heard of STEAM education before?"; %
Source: compiled by the authors

Based on the survey results, where most respondents answered that they had heard of STEAM education, and a small number of participants had not, it can be concluded that the vast majority are familiar with the concept of STEM education, which is a positive indicator. This indicates a certain level of awareness and readiness to adopt innovative approaches to learning. However, a lack of understanding of the concept of STEM education negatively impacts the success of its implementation. This step requires knowledge, practical skills, and the involvement of both learners and educators. Only through the active application of

STEM principles in the educational process can real changes be achieved, namely improving the quality of education and actively implementing its methods in everyday practice.

The survey results, presented in Figure 2, determined that almost half of the respondents were able to increase their motivation to learn thanks to the implementation of STEM education, which is significant evidence that this approach is justified. This means that there is a positive impact of STEM education, indicating its effectiveness in engaging young people in active and innovative learning.

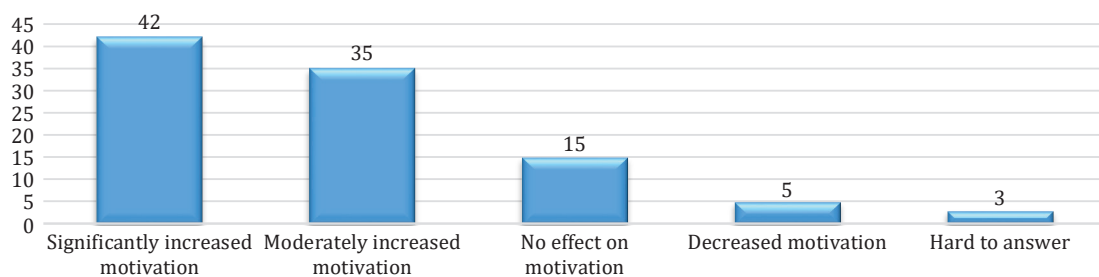


Figure 2. Results of respondents' answers to the question "How has the implementation of STEM education influenced your motivation to learn?"; %
Source: compiled by the authors

This confirms that the implementation of STEM education was the right step aimed at increasing learners' interest in learning and developing their skills in science, technology, engineering, and mathematics. However, to achieve even better results, it is important to continue developing and improving STEM education methods, providing even more learners with the opportunity to benefit from it.

This will not only increase motivation to learn but also contribute to the training of highly qualified specialists who can solve complex problems of the future. Figure 3 revealed that nearly half of the respondents answered that STEM education helps to develop critical thinking, while a small percentage indicated that STEM education hinders the development of critical thinking.

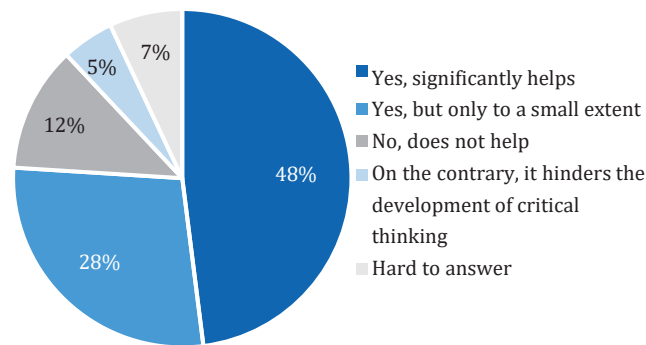


Figure 3. Results of respondents' answers to the question "Does STEM education help you develop critical thinking?"; %
Source: compiled by the authors

These results demonstrate that for almost half of the respondents, STEM education is indeed an effective tool for developing critical thinking. This suggests that the methodologies used in STEM education promote active analysis, problemsolving, and a creative approach to tasks. However, there is a certain proportion of learners who feel that STEM education hinders the development of critical thinking, indicating that the perception and effectiveness of teaching approach-

es can vary depending on individual learner characteristics. This means that the results of implementing STEM education largely depend on the type of learners, their learning styles, and preferences. It is important to adapt STEM education approaches to different types of learners to most effectively develop critical thinking in each of them. The data in Figure 4 underscores the need for flexibility in the educational process and the further development of individualised learning methods.

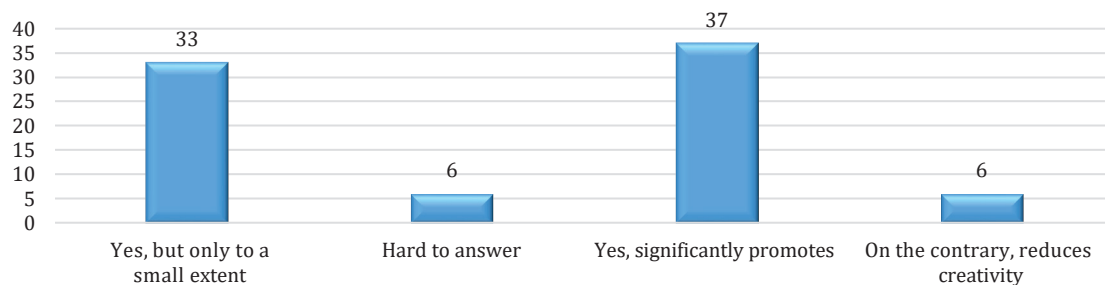


Figure 4. Results of respondents' answers to the question "Does STEM education contribute to the development of your creative thinking?"; %

Source: compiled by the authors

The aforementioned data suggests that while STEM education successfully develops critical thinking in a significant portion of respondents, it does not always fully promote the development of creative thinking. This may be due to the fact that traditional STEM approaches, focused on exact sciences and logical thinking, sometimes do not provide enough opportunities for creativity and the generation of new ideas. It is important to note that to fully develop learners' creative thinking, it is necessary to focus on integrating creative elements into STEM education, such as project work, interdisciplinary approaches, and non-standard tasks. These findings highlight the need to improve STEM education so that it not only develops critical thinking but also actively fosters a creative approach to problem-solving. This will help ensure a more balanced development of different types of thinking in learners, which is important for their future success.

Figure 5 showed that, a significant proportion of respondents indicated insufficient educator preparation, highlighting the need to improve the qualifications and training of educators for the effective implementation of STEM methodologies. A smaller number of respondents mentioned insufficient time for preparation and the implementation of new approaches, suggesting a need to improve the organisation of the educational process and provide educators with sufficient time to master new methods. A significant portion of respondents noted a lack of sufficient technical resources, indicating the need for investment in modern equipment and technologies, which are an integral part of STEM education. In addition, a small percentage of respondents indicated resistance to change from learners, which may indicate the importance of adapting teaching approaches to different types of learners and increasing their motivation to learn through new methods.

Overall, these results highlight the need for a comprehensive approach to addressing the challenges associated with the implementation of STEM education,

including educator training, providing the necessary resources, and supporting learners in the process of adapting to new forms of learning.

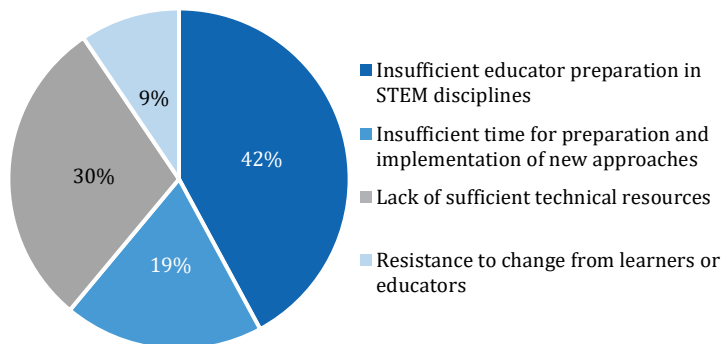


Figure 5. Results of respondents' answers to the question

"What challenges do you observe among educators when implementing STEM education?", %

Source: compiled by the authors

Figure 6 showed that almost half of the respondents rated this impact as very positive. Although this figure demonstrates that almost half of the respondents see significant benefits in STEM education, it can be considered average. This suggests that there is still room for improvement in this area. To achieve better results and maximum effectiveness in the

implementation of STEM education in Ukraine, it is necessary to continue improving teaching methods, providing educators with the necessary resources and support, and actively involving learners in STEM projects. Such an approach will contribute to improving the quality of education and equip learners with the necessary skills for the future.

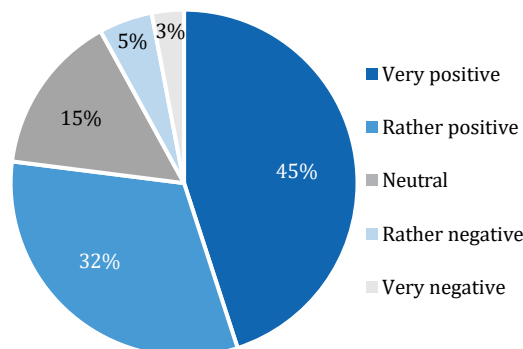


Figure 6. Results of respondents' answers to the question

"How do you rate the overall impact of STEM education on the quality of your learning?", %

Source: compiled by the authors

For the successful implementation of STEM education, high learner motivation is essential, as it is the key factor determining the success of the learning process. Without a sufficient level of interest and engagement from learners, the integration of a STEM approach can become superficial and ineffective. Motivation encourages active learner involvement in the learning process, stimulates them to independently seek knowledge and develop creative thinking. In the context of the rapid development of technology and innovative approaches to learning, learners must not only be knowledgeable but also intrinsically motivated to master complex interdisciplinary skills. An important

aspect is the creation of a learning environment that fosters learners' interest in STEM disciplines. This may involve the application of new teaching methods, the use of interactive technologies, conducting practical classes and project work, which allows learners to see the practical application of the knowledge acquired. It is also important to provide support for educators who can motivate learners through their own example and the provision of interesting and relevant information. Successful learner motivation to master STEM disciplines is not only the key to quality vocational training but also the foundation for the formation of future specialists capable of successfully adapting to the modern

labour market and contributing to the development of an innovative economy.

The questions presented in Table 2 and the corresponding responses allowed for an assessment of the impact of STEM education on various aspects of the learning process, as well as identifying the main challenges faced by educators when implementing this

approach. Specifically, the general trends and opinions of research participants regarding various aspects of STEAM education integration. They demonstrate a high level of awareness of STEAM education, and a predominantly positive attitude towards its implementation, but also indicate significant challenges, such as insufficient resources and educator training levels.

Table 2. Results of respondents' answers to the last research question

Question	Response options	Responses from participants, %
To what extent do you agree that the integration of STEAM education increases learner motivation?	Completely agree	50%
	Agree	30%
	Neutral	10%
	Disagree	8%
	Completely disagree	2%
Do you feel that you have enough resources to implement STEAM education?	Yes	35%
	No	65%

Source: compiled by the authors

The survey conducted among participants to assess the impact of STEM education on their learning allowed not only to obtain important data on the perception of this approach but also to explore potential ways of integrating STEM education into vocational training. These data indicate significant opportunities and challenges faced by learners and educators during the implementation of STEM education. An analysis of the survey results allows for the identification of specific development directions that can contribute to a more effective integration of STEM education into the educational process, particularly in the context of vocational training. The survey results indicated that 45% of respondents rated the impact of STEM education on the quality of their learning as very positive. This suggests that a significant proportion of learners already perceive the benefits of this approach, particularly in developing critical thinking, problem-solving skills, and increasing motivation to learn. However, this figure can still be considered average, indicating a need for further improvement in the integration of STEM education. One potential way forward is to create conditions for a deeper implementation of STEM methodologies into learners' vocational training. This could involve developing specialised training programs that combine theoretical knowledge with practical skills in relevant fields of science, technology, engineering, and mathematics.

One of the main challenges faced by educators when implementing STEM education is insufficient preparation (42% of respondents identified this problem). This means that to successfully integrate STEM education into vocational training, educators must be provided with access to professional development programs that include modern teaching methods focused on developing STEM disciplines. It is also important to involve educators in the process of developing teaching materials that take into account the specifics of vocational training in the relevant fields. In this context, it is

also important to consider the survey results, which indicate insufficient time for the preparation and implementation of new approaches (19% of respondents). This highlights the need to review curricula to provide educators with sufficient time to prepare for teaching STEM disciplines. Technical provision was another significant issue highlighted by 29% of respondents who indicated a lack of sufficient resources. Integrating STEM education into vocational training requires modern equipment and technology that allow learners to acquire the practical skills necessary for their future careers. One way to address this challenge is to develop partnerships between educational institutions and businesses operating in relevant fields. Such partnerships could not only improve technical resources but also create opportunities for joint projects, internships, and other forms of practical training.

Attention should be paid to the 9% of respondents who indicated resistance to change from learners. This suggests that some learners may face difficulties adapting to new teaching approaches. One possible way to address this issue is to create a supportive environment where learners can receive additional help and advice from educators. It is also important to involve learners in the process of discussing and implementing STEM methodologies, which will allow them to feel more involved in the learning process and reduce resistance to change. Analysis of the survey results has revealed both opportunities and challenges associated with integrating STEM education into vocational training. The main areas that should be focused on for successful integration include: upgrading educator qualifications, revising curricula to allow sufficient preparation time, improving the technical equipment of educational institutions, and creating a supportive environment for learners. The result of these measures should be an increase in learning efficiency, preparing learners for work in modern conditions, developing their critical

and creative thinking, and forming the skills necessary for a successful professional career in STEM fields.

Adapting curricula to the demands of the modern digital environment and preparing educators to integrate STEM education faces numerous challenges. In particular, the lack of modern resources and infrastructure. One of the main problems is the insufficiency of modern educational resources and infrastructure for the implementation of STEM education. Many educational institutions lack the necessary laboratories, computers, and software. This limits the possibilities for conducting practical classes and experiments. Many educators do not have adequate training to teach STEM disciplines, especially when it comes to using new technologies and methods. This requires the development and implementation of professional development programs for educators, as well as the involvement of industry experts to conduct training and workshops. Some educators and school administrators may resist the implementation of new methods and technologies due to a preference for traditional approaches. This creates obstacles to the rapid and effective integration of STEM education. The integration of STEM education requires significant financial investment to purchase equipment, develop new programs, and train educators. However, budgetary constraints often hinder the full implementation of innovative approaches. STEM education demands an interdisciplinary approach that combines knowledge from various fields of science, technology, engineering, and mathematics. Nevertheless, in many educational institutions, curricula are designed so that subjects are taught separately, making integration and practical application of knowledge difficult. Another problem is the low motivation of learners to study STEM disciplines. This may be due to a lack of understanding of career prospects in these fields or the complexity of the subjects themselves.

To overcome these challenges, comprehensive measures are needed, including the modernisation of educational infrastructure, the implementation of professional development programs for educators, the development of new teaching materials, and active work to motivate learners. It is also important to create a conducive environment for interdisciplinary collaboration and ensure adequate funding to achieve these goals. It has been determined that to improve educator qualifications and enhance the material and technical resources of educational institutions engaged in integrating STEM education, it is essential to implement regular training sessions and seminars using modern technologies, the latest teaching methods, and an integrated interdisciplinary approach. It is important to involve industry experts and researchers with experience in relevant fields in conducting such events. It is also necessary to create and implement professional development programs for educators focused on developing skills in teaching STEM disciplines. Such

programs may include courses in programming, robotics, and engineering, as well as active learning methodologies. It is necessary to facilitate the exchange of experience among educators from different educational institutions at both national and international levels. This can be achieved through participation in conferences, and workshops, as well as through the organisation of internships and exchange programs. Additional funding sources should be sought, including government grants, sponsorship, partnerships with businesses, and international organisations, to update the material and technical base. Furthermore, it is essential to equip modern laboratories with the necessary equipment for conducting practical classes in physics, chemistry, biology, engineering, and other STEM disciplines. It is important to provide access to modern computers, software, and tools for data modelling and analysis. Integrating modern digital technologies into the learning process, including the use of interactive whiteboards, virtual laboratories, learning platforms, and other innovative solutions, is crucial. A comprehensive approach to enhancing educator qualifications and improving the material and technical resources is key to the successful integration of STEM education into the curriculum. Implementing the proposed measures and continually seeking new avenues and innovations in this field will contribute to improving the quality of education and training highly qualified specialists capable of working effectively in the modern digital environment.

■ Discussion

Research findings indicate that the integration of STEM education into vocational training has significant potential to enhance the quality of graduate preparation. This contributes to increasing their competitiveness in the job market and ensuring the sustainable development of various industries. STEM education enables learners to acquire critically important skills such as analytical thinking, problem-solving, and an innovative approach to tasks. However, the integration process is not without its challenges. These include the need to modernise curricula, prepare educators for new teaching methods, and provide the necessary technical equipment and resources. It is important to develop partnerships between educational institutions and industry to ensure a practical component of learning. Addressing and overcoming these challenges is key to maximising the effectiveness of integrating STEM education into vocational training.

One of the key benefits of integrating STEM education is the improvement of learning outcomes. According to research by Z. Aguirre-Muñoz *et al.* (2024), the STEM approach fosters critical thinking, analytical skills, and creativity. This is supported by the results of this study, which show that learners enrolled in programs that integrate STEM demonstrate higher academic performance and are more confident in their

professional skills. The findings that the modern job market is increasingly oriented towards technology and innovation, making STEM education particularly relevant, align with the study of R. Jamaluddin *et al.* (2023), E.A. Flaherty *et al.* (2023), and A. Saif *et al.* (2023). They found that the demand for professionals with STEM competencies is rapidly increasing. Their results also indicate that graduates of STEM-integrated programs have more opportunities for employment and career advancement than their counterparts from traditional programs. Research findings have shown that STEM education stimulates innovative thinking and the development of new technologies. This has been corroborated by the study of researchers T.-Y. Mou (2023) and V. Veneziano & I. Mahmud (2024), who demonstrated that integrating STEM into curricula fosters the creation of new start-ups and technological developments. Specifically, their research found that learners who studied STEM programs were more likely to engage in innovative activities and participate in start-ups. The data supports this conclusion, demonstrating an increase in the number of new companies and technological solutions emerging from STEM learners. This highlights the importance of integrating STEM education into vocational training, as it not only enhances learners' knowledge but also contributes to economic development by stimulating innovation and technological progress.

One of the main challenges is the insufficient preparation of educators to work on STEM programs. Research by A. King-Kostelac *et al.* (2022) and T. Boz (2023) found that most educators lack the necessary qualifications and experience to effectively teach STEM disciplines. This study aligns with these findings. It was found that educators often encounter difficulties when implementing new methods and technologies in the learning process, particularly due to a lack of adequate resources and infrastructure, as these are necessary for the effective integration of STEM education. The findings of this study demonstrate that the integration of STEM education enhances the quality of graduate preparation. Research by M. Lloyd *et al.* (2023) supports these conclusions and further suggests that learners who have studied STEM programs exhibit higher academic achievement and better developed analytical skills compared to those who have studied traditional programs. This aligns with the results of this study, which indicate an increased level of critical thinking and problem-solving abilities among engineering learners following the implementation of STEM education. Another study by T.P.L. Nguyen (2023) confirmed that graduates of STEM programs have a higher chance of employment and earn higher salaries compared to graduates of other fields. This study also indicates that graduates who have completed STEM programs are in high demand in the job market and are more likely to hold leadership positions in their fields.

The results of the study also showed that STEM education fosters innovation and enhances the competitiveness of entire industries. Countries that actively implement STEM education achieve significant success in technological and economic development. Research conducted by N.V. Valko & V.V. Osadchyi (2021) suggested that many educators lack the necessary knowledge and skills to effectively teach STEM subjects. This aligns with the findings of this study, which highlight the need for professional development among faculty to ensure high-quality teaching. Another challenge is the insufficient material and technical resources in higher education institutions. Research by M. Evagorou (2024) demonstrated that many schools and universities lack the modern equipment and laboratories required for STEM education. This study also indicates that the absence of up-to-date technology and equipment can significantly hinder the learning process and reduce its effectiveness. When implementing STEM education, stakeholders may encounter resistance from proponents of traditional teaching methods. These results are supported by the research of M. Mateos *et al.* (2020) and H.S. Yilmaz (2022), who found that many educational institutions and educators resist change, posing a significant barrier to the active integration of STEM education.

These findings also coincide with the results of other studies in many respects. For instance, research conducted by D.B. Oerther & M.E. Glasgow (2021) and N.T.P. Nguyen & L.H. Tran (2024) confirmed that the integration of STEM education enhances academic achievement and the development of critical thinking skills in learners. Meanwhile, it was found that graduates of STEM programs have a higher level of competitiveness in the job market compared to those who studied under traditional educational programs. In conclusion, the integration of STEM education into vocational training offers vast opportunities to enhance the quality of education, increase graduate employability, and foster innovation within industries. Successful implementation of STEM programs requires curriculum reform, the adoption of innovative teaching methods, and close collaboration with industry partners who can provide up-to-date knowledge and experience. However, this process is accompanied by significant challenges. The inadequate preparation of educators is a key issue that can hinder the development of STEM education. Many educators lack sufficient experience with new technologies and methodologies, limiting their ability to effectively teach STEM subjects. The absence of necessary resources and infrastructure is also a substantial barrier. To successfully implement STEM education, educational institutions must be equipped with modern facilities and resources, which requires significant financial investment. Additionally, resistance to change within the educational environment can create further difficulties. Many educational institutions have deeply rooted traditions and methodologies that are difficult

to change. This requires a comprehensive approach and collaboration among all stakeholders, including governments, educational institutions, businesses, and the public. Only through joint efforts can the existing challenges be overcome, ensuring the successful integration of STEM education into vocational training, which, in turn, will contribute to the development of highly qualified professionals capable of addressing the challenges of the modern world.

■ Conclusions

Rapid globalisation and technological advancements demand new approaches to education to equip young people for the challenges of the future. One such approach is STEM education, an innovative teaching methodology that not only provides in-depth knowledge of core subjects but also develops key skills. It has been found that there are several ways to integrate STEM education, including incorporating STEM into curricula, creating necessary laboratories, conducting relevant workshops on modern educational approaches, and training specialists. A survey of 300 respondents from various fields was conducted to investigate the integration of STEM education into vocational training, its possibilities, and challenges. The survey, conducted using a specially designed questionnaire, identified key aspects of the positive impact of STEM education on vocational training. Results showed that a majority of respondents positively evaluated the implementation of STEM education, noting its positive influence on the learning process and professional development of learners. Certain challenges were identified, such as insufficient educator training and limited resources. The data obtained formed the basis for formulating potential stages for improving the integration of STEM education into vocational training. It is confirmed that the integration of STEM education into vocational training significantly improves the quality of education and graduate preparation. Respondents indicated that the implementation of STEM education fosters critical thinking, problem-solving skills, and analytical

abilities, which are essential for successful professional careers. STEM education stimulates innovation, equips learners with practical skills necessary for working in a modern technological environment, and provides a better understanding of interdisciplinary connections, crucial for a comprehensive approach to solving professional challenges.

The survey results suggest that STEM education not only enhances technical skills but also promotes the development of soft skills such as teamwork and communication, significantly increasing graduates' competitiveness in the job market. Another important aspect is that integrating STEM into vocational training allows for better alignment of educational programs with the needs of the modern job market, leading to more effective workforce development. The research also identified several challenges that require further attention. Among the main obstacles are insufficient educator training, a lack of integrated curricula, and the need for significant financial investment to modernise equipment and teaching materials. A significant issue is also the absence of unified standards for evaluating the effectiveness of STEM education, which complicates the assessment of implementation outcomes. Promising avenues for future research include developing new models for integrating STEM education into various educational systems, studying the effectiveness of different teaching methods and their impact on professional preparation, and analysing successful practices of STEM education implementation in an international context. A limitation of this study is the limited geographic scope of the survey and the potential influence of respondents' subjective assessments on the results. To obtain more objective data, it is necessary to expand the research to a larger number of respondents and regions.

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■ Conflict of Interest

None.

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Інтеграція концепції STEM/STEAM-освіти в професійну підготовку майбутніх фахівців у сфері туризму і рекреації: можливості та виклики

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■ **Анотація.** Метою даного дослідження було виявлення шляхів вдосконалення професійної підготовки майбутніх фахівців у галузі туризму і рекреації, формування необхідних компетенцій завдяки впровадженню концепції STEM/STEAM освіти. Методологія дослідження включала якісні та кількісні методи збору даних, зокрема опитування студентів та викладачів, аналіз навчальних програм і спостереження за навчальним процесом. Ці підходи дозволили зібрати як якісні, так і кількісні дані за допомогою анкет, для вивчення досвіду, ставлення та думок учасників. Основні результати дослідження показали, що інтеграція STEM-освіти в професійну підготовку значно сприяє розвитку ключових навичок, необхідних у сучасному світі, таких як креативність, критичне мислення, технічна грамотність та міждисциплінарна співпраця. Було виявлено, що студенти, які навчаються за STEM-програмами, демонструють вищий рівень мотивації до навчання, що зумовлено застосуванням практично орієнтованих підходів та інноваційних технологій. Дослідження виявило кілька викликів, зокрема недостатню підготовку викладачів до роботи в межах STEM-підходу та обмеженість ресурсів, що ускладнює ефективну реалізацію таких програм. Підкреслено важливість підтримки з боку адміністрації закладів освіти та необхідність співпраці з партнерами для успішної інтеграції STEM-освіти. Незважаючи на ці виклики, потенціал STEM-освіти залишається високим за умов належної підтримки та адаптації до локальних умов. Важливим аспектом було те, що STEM-освіта має значний потенціал для покращення професійної підготовки, її впровадження супроводжувалося певними викликами. Встановлено важливість підтримки з боку адміністрації закладів освіти та необхідність співпраці з партнерами для успішної інтеграції STEM-освіти. На основі отриманих результатів встановлено, що для ефективного інтеграції STEM-освіти необхідно проводити постійне навчання викладачів, забезпечувати необхідні ресурси та активно залучати до процесу всі зацікавлені сторони. Отримана інформація може бути використана освітніми установами для впровадження інноваційних методів навчання та створення сприятливих умов для розвитку навичок, необхідних у сучасному світі

■ **Ключові слова:** концепція STEM/STEAM освіти; професійна освіта; майбутні фахівці у сфері туризму і рекреації; інноваційні технології; інтегрований підхід; міждисциплінарні програми; професійна компетентність